DYNAMIC FUZZY LOGIC-BASED QUALITY OF INTERACTION WITHIN BLENDED-LEARNING: THE RARE AND CONTEMPORARY DANCE CASES

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ABSTRACT

The combination of the process of pedagogical planning within the Blended (b-)learning environment with the users' quality of interaction (QoI) with the Learning Management System (LMS) is explored here. The required QoI (both for professors and students) is estimated by adopting a fuzzy logic-based modeling approach, namely *FuzzyQoI*, applied to LMS Moodle data from two academic years of two dance disciplines, i.e., the Rare and Contemporary ones. The distribution of the estimated QoI across the segmented time-period of the each academic year for each user's type and for each discipline show the beneficial role of QoI to shift the educational scenarios and strategies towards a more dynamic design, yet taking into consideration the inherent tendencies and attitudes of the users' interaction within the b-learning context. These are revealed as causal relations in the LMS interaction patterns between users, along with dynamic variations in their individual attitude when interacting with LMS. The findings presented here could shed light upon designing factors of educational scenarios, in general, but also to those involved in cultural preservation and exploitation initiatives, such as the i-Treasures project (http://i-treasures.eu/).

KEYWORDS

Blended-learning, LMS, Quality of Interaction, Fuzzy Logic, Rare and Contemporary Dance, i-Treasures.

1. INTRODUCTION

The extraordinary development of the Information and Communication Technologies (ICTs) in Education has influenced the Higher Education Institutions (HEIs) to adopt online learning solutions/environments. Universities and educators are challenged to provide quality in online learning environments (OLE), since teaching and learning paradigms are emerging and, in general, students are more open in taking online courses. In higher education, there are mainly two well-known modalities for online learning, namely: fully online learning and blended(b-) learning courses (Bates and Sangrà, 2011). For fully online courses, all course materials are provided via the OLE without any face-to-face (F2F) component. For the b-learning case, also known as hybrid or combined mode course, both F2F and online class components are considered. Globally speaking, many people live their lives in a "blended" way, combining physical and online activities/experiences. Here, the b-learning concept not only fits into the contemporary, connected lifestyle, but also provide particular gains to students, teachers, and administration, namely: i) increased access and convenience; ii) improved learning; and iii) decreased (or more flexible) costs (Stein and Graham, 2014).

1.1 Interaction in b-learning Environments

In general, the Learning Management Systems (LMSs) provide educators an environment to place their online course materials and for students to receive that education while interacting with other students/teachers. However, students' interactions, attention and communications are seen as relatively low in the LMSs (Musbahtiti and Muhammad, 2013).

Anderson's online pedagogical model (Anderson, 2004) is based on three types of interactions presented by Moore (1989), i.e., student-student interaction, teacher-student interaction, and student-content interaction. Anderson's OLE primarily focuses on independent and collaborative learning, highlighting the importance of the role of the interaction. It is also known as a model of e-learning, which allows structuring and organizing online learning through six particular types of interaction, i.e., teacher-content, content-student, student-student, student-teacher, student-content and content-content. Indeed, the two identified actors (teacher and student) interact with each other and with the contents. During this interaction, a wide variety of activities (synchronous and asynchronous) can be used, based on the Internet (e.g., audio, video, conferencing, chats, and virtual worlds). These environments are particularly enriched, promoting the development of social skills and collaborative work, as well, at the level of interpersonal relationships between the participants (Anderson, 2004). In fact, Anderson's online pedagogical model can be interpreted and analyzed in two separate parts. In the first part, students can interact with the content that is available in various formats (especially with Web tools), or they can choose to have their learning in a sequential way, i.e., guided and evaluated with the help of the teacher. This interaction can be seen as a community that is mainly stimulated by the use of various e-activities, synchronously or asynchronously, supporting social interaction, collaborative learning content and the development of interpersonal relationships. In the second part, learning tools are based on independent learning; however, even if guided to independent study, the students continue to be followed, since they share the same workspace with other colleagues or peers-to-peers connections that ensure permanent cooperation and communication interfaces. Considering that both b-learning and LMSs opportunities are growing, it is important to understand about the type of interaction available in the OLEs and the way it defines the quality of interaction (QoI). According to Parker (1999), the lack of interaction is considered an important obstacle to online learning; however, several improvements in ICTs over the last years have enhanced the QoI in online environments. From this perspective, there are five types of interactions that educators can consider into the curriculum, namely: i) learner to instructor; ii) learner to learner; iii) learner to content, learner to tools, and learner to environment (Bastedo and Vargas, 2014). At the same time, there is a variety of tools that assist in facilitating interaction in online learning. These tools have been classified into two different categories, i.e.: asynchronous (e.g., quizzes, discussions) and synchronous (e.g., online chat) technologies. Considering the main concepts regarding interactions in OLEs and the corresponding tools/resources that facilitate those interactions, it may still be difficult to decide when and which tool will fit better into an online course. Here, it is important to select the interactions and tools/resources according to the need of the learning goals. In addition, different areas should be considered when an online course is created, namely: 1) course content; 2) delivery of instruction; 3) communication and interaction; 4) student time spent on learning tasks; and 5) assessment of student learning (Zhu et al., 2003). Although the course content may be the same, the delivery of instruction may be given in both modalities (synchronous or asynchronous). Among others, the selected assessment activities can be done using chats, forum discussion, assignments or quizzes. However, since each OLE is unique, the role of the educator is to assess their OLE and determine/adapt if changes are necessary or not.

Taking into account the users' interactions (professors' and students') through the LMS use within a b-learning environment, here, the *FuzzyQoI* model (Dias and Diniz, 2013; Dias et al., 2014a) is adopted. The latter is used as a translator of the knowledge of the experts in the field into fuzzy constructs, and estimates, in a quantitative way, a normalized index of the users' QoI across two consequent academic years at a HEI. This process is exemplified here with two dance paradigms, i.e., Rare and Contemporary Dance disciplines at a HEI, serving as a bet-set for the realization of b-learning scenarios within the i-Treasures project (http://i-treasures.eu/), related with the capture of the Intangible Cultural Heritage (ICH) and learning the rare know-how of living human treasures (FP7-ICT-2011-9-600676-i-Treasures) (Dias et al., 2014b).

2. METHODOLOGY

In the effort to develop a successful evaluating system of the user's interaction with the LMS through the QoI, intelligent systems may play an important role, i.e., provide a model of the domain expert's evaluating system, with the promise of advanced features and adaptive functionality (Levy and Weld, 2000). Based on the latter, a Mamdani-type (Tsoukalas and Uhrig, 1996) fuzzy logic-based QoI modelling, namely *FuzzyQoI* scheme, was proposed by Dias and Diniz (2013). The *FuzzyQoI* model constitutes a Fuzzy Inference Systems

(FISs) structure that is able to produce evaluative inferences upon input data. In particular, the latter correspond to the key-parameters and variables (metrics) of LMS Moodle (https://moodle.org) involved within a b-learning environment concerning the user's interaction with the system, whereas the outputted inference forms a quantitative measure of the user's overall QoI (Dias and Diniz, 2013).

Generally speaking, the users (professors/students) interact with the LMS and the available 110 LMS Moodle metrics are corresponded to 12 categories that serve as inputs to the FIS structure. In an effort to efficiently handle the 12 input variables, these are grouped into three groups and a nested sequence of five FISs (FIS1-FIS5) is used to form the proposed *FuzzyQoI* scheme.

For the construction of the knowledge base of the FuzzyQoI scheme, an expert in the field of analyzing LMS Moodle data within the context of b-learning was used, for defining the structure of the membership functions used for each FIS and the corresponding IF/THEN fuzzy rules. In particular, a three-level of trapezoid membership functions corresponding to Low, Medium and High values, respectively, were used for the FIS1-FIS4, whereas a five-level of trapezoid membership functions corresponding to Very Low, Low, Medium, High and Very High values were adopted for the final FIS5, increasing, this way, the resolution in the segmentation of the universe of discourse in the final FIS5.

Analytical description of the *FuzzyQoI* model can be found in Dias and Diniz (2013).

2.1 Pedagogical Planning

The organization of educational scenarios during the LMS interaction is facilitated here with the adoption of the Pedagogical Planning (PP) (Olimpo et al., 2010). The realization of the latter is achieved by adopting the MindMup tool from the i-Treasures Pedagogical Planner (Bottino et al., 2013), which is a scalable cross-browser Web-based application developed in PHP, MySQL and JavaScript. The PP is essentially a teacher-oriented online tool, yet in the way it is used here, it could serve as a combinatory tool that incorporates both designing and planning of the educational interventions and feedback from the realization of the b-learning delivered instruction. In this way, causal relations between professors' and students' at the level of their LMS-based QoI could be identified and professors' metacognitive processes could be fired towards the enhancement of their pedagogical planning and delivery. The PP comprises of both authoring and display capabilities, with specially designed functions and interface features in both cases. In particular, target population, learning context, content domain, objectives and metrics, along with available tools (such as MindMup), are the core characteristics of the PP (http://i-treasures.eu/).

To exemplify the combination of the FuzzyQoI model with the Pedagogical Planner two cases that resemble the use-cases of the i-Treasure project, i.e., the Rare and Contemporary Dances, are used as paradigms and described in the subsequent section.

2.2 The Rare and Contemporary Dances Cases

Rare Dances at the FHK, actually, belong to the Social Dances discipline, which aims to provide and develop ways to dance, able to contribute to a students' education in a more complete, comprehensive and multifaceted way, through the diversity of approaches and multiplicity of perspectives developed in each dance form. Moreover, the social dimension and respect of the act of dance are taken into account to enhance the knowledge and extend the application domain with multicultural approaches, revealing the nature and specificity of their contents. The planning of this discipline aims to construct a place of experience and experimentation with different materials, choreographic and contextual, along with specific techniques for analysis, leading to "know-how" and the enlargement and consolidation of formal and expressive repertoire of the students.

Contemporary Dances at the FHK are included in the Techniques of Theater Dances discipline, which aims to promote the analysis and study of motor vocabulary characteristic of modern and classical dance forms. The PP includes practice of standardized modeling steps organized in simple exercises with repetitions and chained in sequence dances increasing complexity. Moreover, training skills of observation in situations of mutual learning, are also considered, being consistent with the principles and quality of dance movements. Figure 1 illustrates the PP of the both paradigms (Rare and Contemporary Dance) in the form of the MindMup output, where the principal components, i.e., scientific domains, learning objectives, b-learning context, LMS Moodle tools and forms of assessment, are shown in the form of connected branches.

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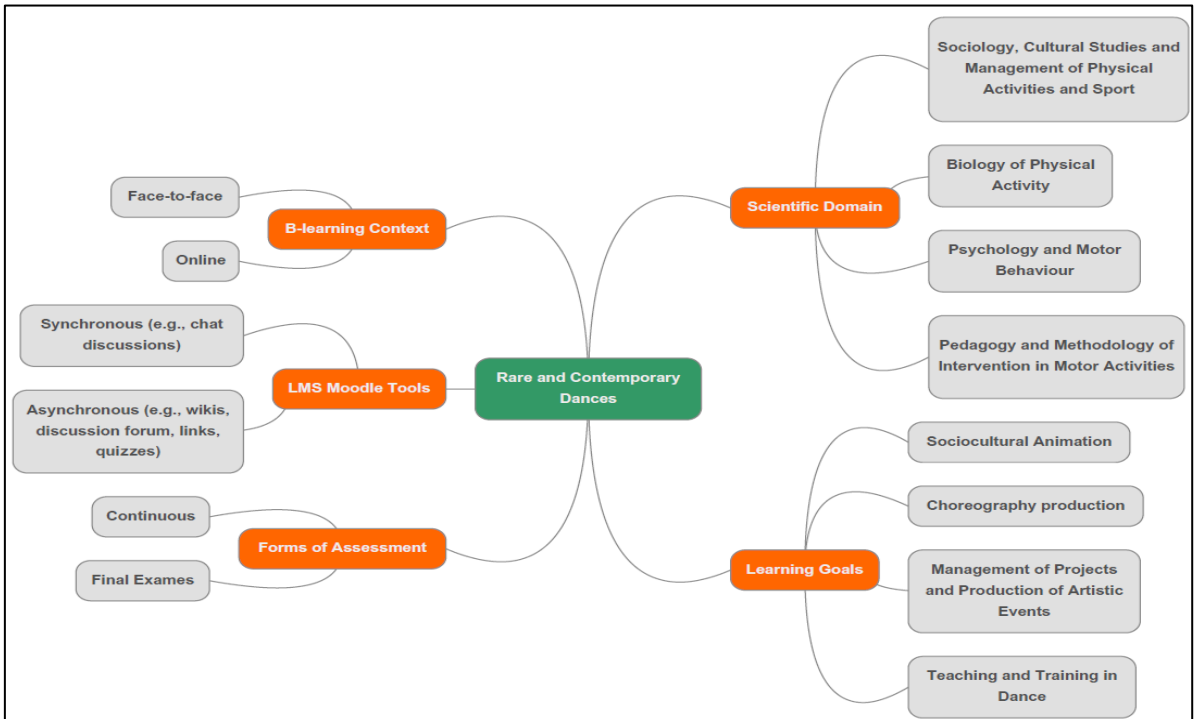

Figure 1. The MindMup output of the PP of the Rare and Contemporary Dances with the main elements (i.e., scientific domains, learning goals, b-learning context, LMS Moodle tools and forms of assessment).

3. DATASET USED

The FuzzyQoI (Dias and Diniz, 2013) was applied to LMS Moodle data from two dance disciplines, i.e., Rare and Contemporary Dances, drawn from the Faculty of Human Kinetics (FHK), University of Lisbon, Portugal, where the corresponding dance disciplines are realized within the b-learning context. For each paradigm (Rare and Contemporary Dance), the 110 LMS Moodle metrics data for two academic years (Y1: 2009-2010, Y2: 2010-2011) from two teachers (combined teaching) and students from [Rare Dance: 29 (Y1) and 57 (Y2); Contemporary Dance: 43 (Y1) and 55 (Y2)], respectively, were used and analyzed. In order to identify any possible changes in the users' interaction behavior correlated with a specific time-period section, a time-period segmentation was adopted. The latter has resulted in time-period sections (e.g., semesters (S1: 2-16, S2: 23-38 weeks), exam periods (1^{st}: 18-23, 2^{nd}: 38-46 weeks), interruptions (16-18, 24-25; 30-31 weeks)) that served as landmarks in 51-week total examined period.

4. RESULTS AND DISCUSSION

4.1 The Rare Dance Case

Figure 2 depicts the estimated QoI and its mean value $\overline{QoI} \pm std$ (grey area) from the FuzzyQoI model for the Rare Dance case across the two academic years examined (2009/10-top and 2010/11-bottom). In particular, QoI values from the Professors and Students are illustrated in the left and right panels, respectively. In Figure 2, the vertical lines denote the specific weeks that define the time-period segmentation.

Focusing at the Professors for the Rare Dance case (Figure 2-left panel), a reduced QoI is seen in both ones during the academic year of 2009/10, with Professor 2 being more active with the LMS, compared to the Professor 1, exhibiting QoI values around 0.5, both at the first and the second semester. On the other

hand, Professor 1 exhibits QoI around 0.4, only at the end of the first semester. This absence of high QoI values is also noticeable in corresponding $\overline{QoI}$ values, which exhibit a clear reduction across the first semester and some local increases during the second one. Shifting to the succeeding academic year of 2010/11, Professor 1 shows increased QoI values (0.4-0.5) only at the 2nd exam period (38-46 week), whereas Professor 2, like during 2009/10, exhibits increased QoI both at the two semesters, especially at the beginning, mid and end of them, accordingly. These local bursts of QoI values are also evident in the corresponding $\overline{QoI}$ values. Since the two professors are the same across the two sequential academic years, it seems that, in general, they adopt a conservative approach to the involvement of online material and LMS interaction within their curriculum, being its users themselves. Basically, transition points in the time-period (such as beginning/ending of semesters, exam period) seem to motivate more the professors to interact with the LMS, although the latter is not sustained across the whole academic year.

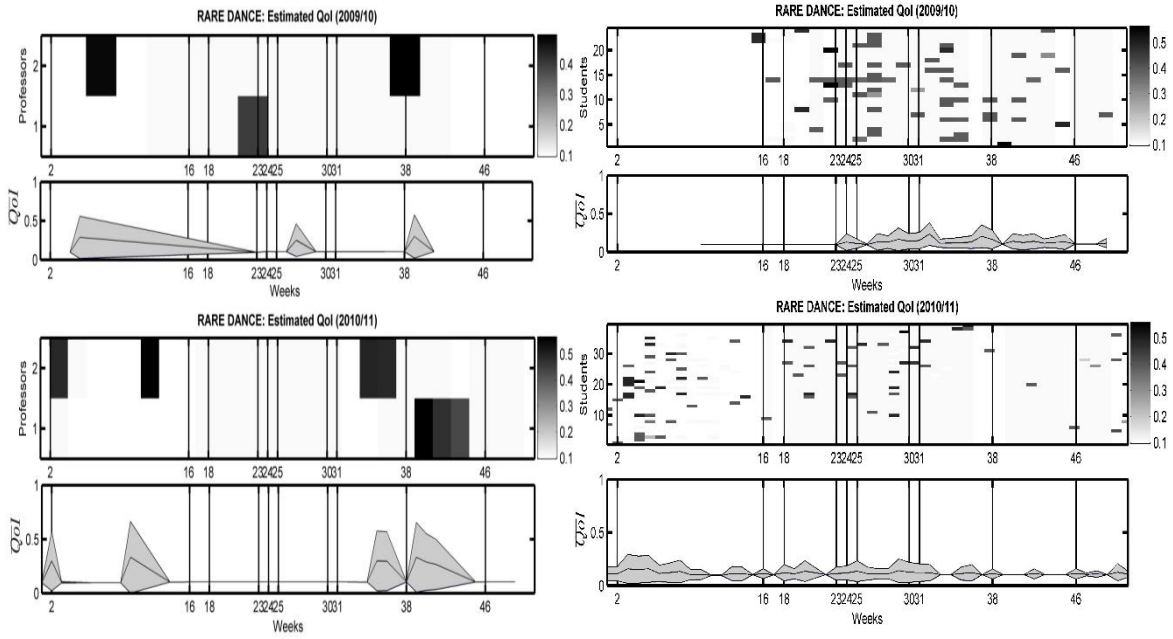

Figure 2. The estimated QoI and its mean value $\overline{QoI} \pm std$ (grey area) from the *FuzzyQoI* model for the Rare Dance case across the two academic years examined (2009/10 and 2010/11). Left panel: Professors; Right Panel: Students. The vertical lines denote the specific weeks that define the time-period segmentation.

Looking at the Students for the Rare Dance case (Figure 2-right panel), the absence of interaction across the first part of the first semester of 2009/10 (weeks 2-16) is evident (also at the corresponding $\overline{QoI}$ values). Then, a sparse activity of QoI values is seen, maximized at the beginning of the second semester and sustained almost across the rest part of the academic year, yet not by all students. This behavioral 'landscape' is reversed at the next academic year (2010/11), where the LMS activity and the achievement of QoI values around 0.5 concentrate at the beginning of the first semester, are reduced as the semester evolves, are sustained across the 1st period of exams and gradually are reduced towards the 2nd period of exams. It is noteworthy, that some students continue to interact with the LMS exhibiting good QoI even after the end of the 2nd exam period (weeks 46-51). By comparing the $QoIs$ from the two academic years in the case of Rare Dance, and taking into account that the students involved are different yet the two professors are the same, it could be seen that in both years, students exhibit higher QoI values at the time-period just after Christmas' interruption (week 18) up to the beginning of the 2nd period of exams (week 38), following, somehow, a hysteresis QoI pattern compared to the professors' one.

4.2 The Contemporary Dance Case

Moving to the Contemporary Dance case, Figure 3 illustrates the corresponding results as the ones depicted in Figure 2, respectively. Nevertheless, in general, the interaction with the LMS is clearly different in the Contemporary Dance case, as both Professors are more interactive, compared to the ones from the Rare Dance case (Figure 2-left panel). For example, as it is shown in Figure 3-left panel, Professor 2 exhibits sustained QoI values around 0.5 across almost the whole period of semesters and exam periods (weeks 4-43) for the academic year of 2009/10. Professor 1 follows a similar pattern, yet a more sparse one. It is interesting to notice that both of them reduce their QoI with the LMS at the next academic year (2010/11), with Professor 1 activating it only in the middle of the 2nd exam period (week 41) and Professor 2 keep it active only until the end of the Easter interruption (week 31). Looking at the QoI results for the case of Students (Figure 3-right panel), QoI values around 0.4-0.5 are sustained almost for the whole duration of the two academic years, yet with a more uniform distribution appearing especially across the 2009/10. By comparing the $QoIs$ from the two academic years in the case of Contemporary Dance, and taking into account that the students involved are different yet the two professors are the same, it could be seen that in both years, students are almost synchronized with the professors' QoI pattern, exhibiting increased QoI at the same week or the one just after the one noticed in the professors' case (see for example weeks 3-6, 17-18, 23-25 for the academic year of 2010/11).

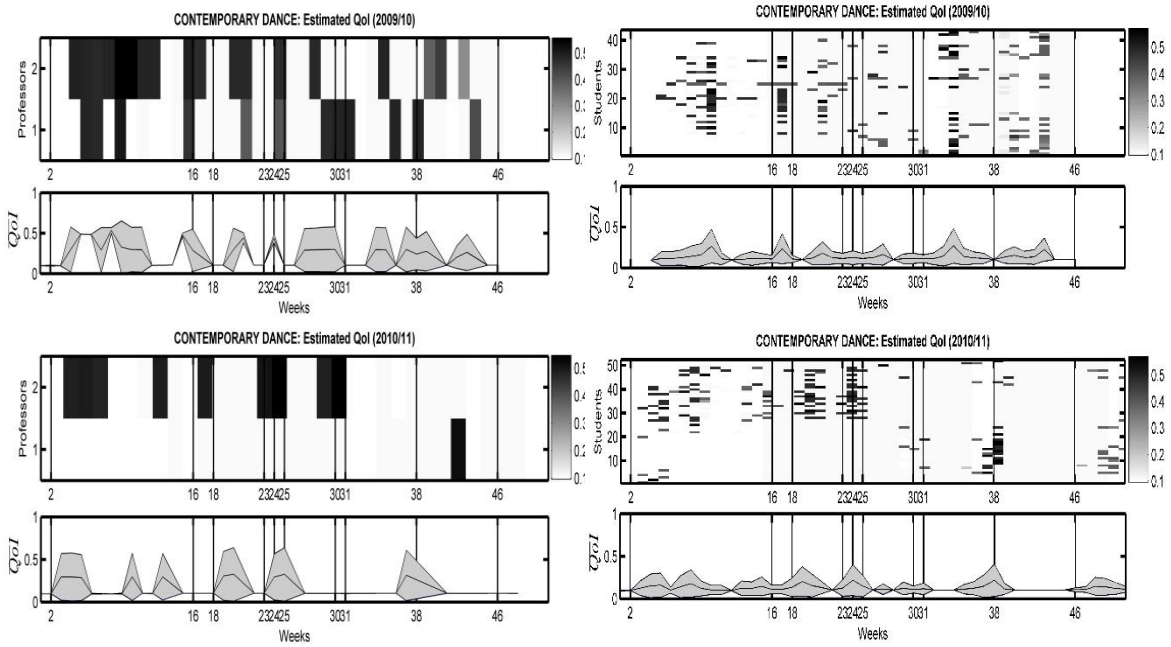

Figure 3. The estimated QoI and its mean value $\overline{QoI} \pm std$ (grey area) from the *FuzzyQoI* model for the Contemporary Dance case across the two academic years examined (2009/10 and 2010/11). Left panel: Professors; Right Panel: Students. The vertical lines denote the specific weeks that define the time-period segmentation.

4.3 Dynamics of *QoI*

From the results presented in Figures 2 and 3 it is evident that the *FuzzyQoI* model provides a useful index, i.e., the QoI, to represent the behavior of the stakeholders involved with the online teaching and learning processes, that is Professors and Students. Apparently, the distribution of QoI across the whole academic year reveals the dynamics underlying within the profiles of both Professors and Students. This is further reinforced, when QoI is examined across subsequent academic years (as the two ones examined here) and for different disciplines (as the Rare and the Contemporary Dance analyzed here). In this way, ups and downs in the QoI of interaction (both from Professors and Students) could be associated with the time-period segmentation, revealing the influence of the structure of the academic year, in terms of formal teaching, interrupting and examining time periods, to the interaction attitude with LMS.

To further elaborate this finding, the distribution of the students' number that exhibited $QoI > 0.1$ for the two semesters of each academic year and for the two examined cases (Rare and Contemporary Dance) was estimated and illustrated in Figure 4, along with the corresponding time-period segmentation. It should be noted that this analysis was restricted to the students' case only, as the number of professors (just two) did not allow for any valid statistical perspective. For the Rare Dance case and the academic year of 2009/10 (top left panel), the students exhibited zero interaction with the LMS at the first semester, whereas, at the second one, they were clearly interacting with the LMS, mostly at the before and during the 2nd exam period. In 2010/11, a more balanced LMS interaction is noticed across each semester, exhibiting almost similar patterns in both semesters. Interestingly, the latter is also noticed in the case of Contemporary Dance for both semesters and for both academic years, in general.

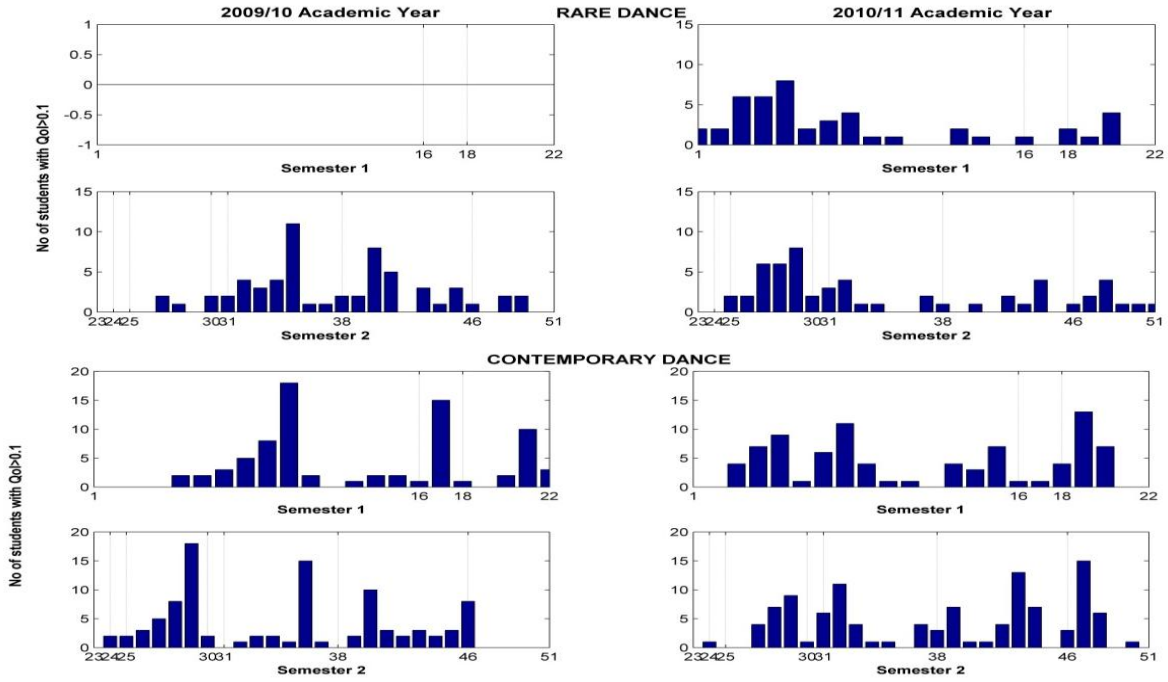

Figure 4. The distribution of the students' number that exhibited $QoI > 0.1$ for the Rare (top panel) and Contemporary (bottom panel) Dance cases, across the two semesters of the two academic years examined (2009/10-left panel and 2010/11-right panel). The vertical lines denote the specific weeks that define the time-period segmentation.

An interesting finding resulting from Figures 2-4 is the way the discipline affects not only the frequency of interaction but also the QoI with LMS, both in Professors and Students' cases. Clearly, the discipline of Rare Dance is restricted to more traditionally defined concepts that follow historical paths and are strongly connected to tradition aspects. In that case, LMS-based activities should convey such information as much as possible, taking into consideration the nature of each rare dance, as well as the students' interests aiming to provide a balance between intellectual tasks (reading, viewing) and interactive tasks, as well as, between group activities and practical experience away from the computer, in order to actively engage students and help them to both understand the dance context, as well as, to learn how to dance. Nevertheless, in the case of Contemporary Dance, more abstract dance issues are examined, supporting LMS-based interactive tasks, so the students could make connections across subject and content areas, thus facilitating their creative thinking and enhancing learning in other subjects as well (e.g. music, history, culture, etc.), making the learning process creative and more motivating. The findings here support these distinct perspectives between Rare and Contemporary Dance disciplines, revealing the way their differences are reflected into the realization of the online component of the b-learning context under a common PP (see Figure 1). The latter could be very useful for effective designing of educational scenarios within the concept of sustaining the cultural heritage, such as teaching rare dances to young generations (New Millennium Learners) and build upon tradition to create a contemporary output, using LMS-based b-learning and the QoI metric, as in the case of the i-Treasures project (http://i-treasures.eu/).

5. CONCLUSION

The exploration of the dynamics of the *QoI* with LMS, both by Professors and Students at a HEI b-learning context, was attempted here. Two disciplines of dance, i.e., the Rare and Contemporary ones, were taken as the analysis focus, and 110 metrics from the LMS Moodle users' interaction across two consequent academic years (2009/10 and 2010/11) were drawn and used as input to a recently developed fuzzy logic-based model, namely *FuzzyQoI*. The latter outputs the metric of QoI, translating the expert knowledge to a series of fuzzification/defuzzification processes. The distribution of the estimated QoI across the segmented time-period of the each academic year for each user's type and for each discipline revealed causal relations in the LMS interaction evolution patterns between Professors and Students, along with dynamic variations in their individual attitude within the online learning environment. These findings could be incorporated into initiatives that involve the design of educational scenarios (such as i-Treasures), especially for cultural preservation, exploration and evolution, such as the b-learning trajectory from rare dances to the contemporary ones.

ACKNOWLEDGEMENTS

This work has been supported by the EU Seventh Framework Programme FP7-ICT-2011-9-ICT-2011.8.2, under the grant agreement n° 600676: "i-Treasures" Project (http:/i-treasures.eu) and by the Foundation for Science and Technology (FCT, Portugal) (Grant SFRH/BPD/496004/2013). The authors would like to thank Dr. C. Ferreira at FHK for his assistance in the retrieval of the LMS Moodle data.

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